Hubble Facts

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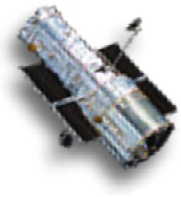

Hubble Space Telescope

Prospects for Hubble Space Telescope Science Operations Under 2-Gryo Pointing Control

Background
Among all the possible future modifications to HST operational procedures that might increase observatory lifetime, the most important is likely the possibility of performing science operations with only 2 functional gyros. The high-precision gyros needed to enable adequate pointing control of HST are the items most frequently requiring replacement – some or all of the gyros have been replaced to date on Servicing Missions 1 and 3A. Extra gyros are always carried on all servicing mission flights to cover the contingency of gyro-failures shortly before mission execution. All current HST 3-axis inertial control modes require 3 functional gyros and HST's experience-based model forecasts less than a 50% probability of having 3 functioning gyros by late-2005 or early 2006. If Servicing Mission 4 (SM4) is substantially delayed beyond the current May 2005 or if it is desired to operate HST to 2010 or beyond without a future servicing mission beyond SM4, it is unlikely the currently-required 3 gyros will be available to maintain continual operations till the nominal end-of-mission. The HST Program Office is therefore studying the feasibility of operation under only 2 gyros – with the goal of ensuring a telescope jitter of no more than 30 milli-arcseconds. If the jitter can be kept below this value, HST will be able to continue world-class science in the absence of 3 operational gyros, although the nature of the observing program might have to be altered somewhat to accommodate resultant constraints on slew speed between targets, portions of the sky accessible at a given time of year, and the time necessary to acquire targets – all of which are under active evaluation at this time (mid-July, 2003).

Goals of Development Effort
The goals of the current effort are centered on studying the feasibility of and attempting to define a 2-gyro control law which meets two criteria. This first is that it produce a mean telescope jitter of < 20-30 milli-arcseconds, compared to the 7 milli-arcseconds obtained under the current 3-gyro control scheme. The second is to do this while simultaneously maintaining a reasonable scheduling efficiency.

These increased jitter limits will have some direct impact on science, but it is mostly limited to the highest resolution imaging modes and narrowest slits used in the spectroscopic instruments – and the primary effect is to increase exposure times, rather than to make any particular science

undoable. It may thus decrease the total number of imaging observations possible at the faintest magnitudes and the total number of ultra-high-resolution spectra obtained by HST – but the overall effect on the program is expected to be modest.
The goal of maintaining reasonable scheduling efficiency presents a greater challenge and the impact that resultant changes in telescope efficiency may have on the science program are potentially larger than the impact of modestly increased jitter. The impacts under study are related to several factors. Longer slew times may be needed when moving from target to target and it may take longer to acquire a target at the end of such a maneuver. The fraction of the sky observable at a given time of year may also be reduced compared to that usable under 3-gyro control. It is likely that careful and clever scheduling processes and alterations in the content of the observing program can ameliorate these problems, but a definitive answer awaits a final determination of the expected performance of the 2-gyro control laws in these areas.

Implementation Requirements
The 2-gyro science mode requires substantial re-architecting of flight software, commanding, and the science planning and scheduling system. There are a number of specific requirements for implementation of the 2-gyro mode, including:

- 3 new attitude control laws using:
  - 2 Gyro/Magnetometer
  - 2 Gyro/Fixed Head StarTracker
  - 2 Gyro/Fine Guidance Sensor
- safemode test changes, including a new 2-gyro safe mode to support transitions from Hubble's deepest hardware safe mode (PSEA, or Payload Safe Mode Electronics Assembly) to 2 Gyro/Magnetometer mode
- new telemetry handling and processing procedures
- new long and short-term scheduling algorithms that sequence and order observations efficiently
- commanding to control the new target acquisition methodology

Benefits of a 2-Gyro Science Mode
Development of this mode would provide a significant reduction in the risk that the science program would be suspended:

- while waiting for resumption of Space Shuttle servicing flights
- between SM4 and the nominal end of mission in 2010 or beyond

Availability of this mode would also provide an additional mode, controlled by the HST 486 computer, for rendezvous and grapple operations by Shuttle. This reduces the chance of having to enter PSEA Safe Mode, which is dependent on use of the non-redundant, limited lifetime, mechanical gyros (RMGA's), a very-limited resource.

It is important to note that if the 2-gyro mode is implemented after the number of operational gyros is down to two, it will provide us another ~ 15 months of science operations.

Time Required to Implement a 2-Gyro Science Operations Mode
Assuming that the technical problems noted above can be solved, implementation of this mode is expected to require approximately 22 months to achieve initial operational capability.